ORAL HEALTH STATUS AND ITS IMPACT ON ACADEMIC PERFORMANCE OF YOUNG ADOLESCENTS IN JAZAN, SAUDI ARABIA

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ORAL HEALTH STATUS AND ITS IMPACT ON ACADEMIC PERFORMANCE OF YOUNG ADOLESCENTS IN JAZAN, SAUDI ARABIA

by,

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بِسْمِ اللهِ الرَّحْمٰنِ الرَّحِيْمِ

In the name of Allah, the most gracious and most merciful.

"Recite: In the name of thy Lord who created man from a clot. Recite: And thy Lord is the Most Generous Who taught by the pen, taught man that which he knew not."

-Quran, 96:1-5

This thesis is dedicated in the loving memory of my late father; Mir Mustafa Ali Quadri (May Allah have mercy on him and grant him the best place in heaven).
I would also like to dedicate this thesis to the most hardworking, motivating, caring and forgiving person in my life, my mother Mrs Kulsum Quadri. You are one of the reasons that I could pursue my higher education. Love you mom.
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List of Abbreviations

AP	Academic Performance
APRS	Academic Performance Rating Scale
A-APRS-15	Arabic-Academic Performance Rating Scale
Child-OIDP	Child Oral Impacts on Daily Performances
CPQ	Child Perception Questionnaire
Child-OHIP	Child Oral Health Impact Profile
CPITN	Community Periodontal Index of Treatment Needs
DMFT	Decayed Missing and Filled Teeth
dft	Decayed and Filled teeth in primary dentition
DT	Caries Teeth Severity
MT	Missing Teeth Severity
FT	Filled Teeth Severity
1+D	Caries Teeth Prevalence
1+M	Missing Teeth Prevalence
1+F	Filled Teeth Prevalence
GI	Gingival Index
HIC	High-income countries
LMIC	Low- and middle-income countries
OH	Oral health
OHRQoL	Oral Health-Related Quality of Life
OIS	Oral Impact Score
EMRO	WHO Regional Office for the Eastern Mediterranean
AFRO	WHO Regional Office for Africa
AMRO/ PAHO	WHO Regional Office for the Americas
EURO	WHO Regional Office for Europe
SEARO	WHO Regional Office for South-East Asia
WPRO	Regional Office for the Western Pacific
GPA	Grade Point Average
MoH	Ministry of Health
LED	Light Emitting Diode
STS	Standard Test Score

STATUS KESIHATAN MULUT DAN KESANNYA TERHADAP PRESTASI AKADEMIK REMAJA MUDA DI JAZAN, ARAB SAUDI

Abstrak

Selain daripada kesan fizikal, psikologi, dan sosial, penyakit mulut pada kanak-kanak telah dikaitkan dengan prestasi sekolah yang buruk yang mempengaruhi potensi kehidupan penuh di kemudian hari. Penyelidikan terdahulu telah mengkaji pelbagai keadaan kesihatan mulut menggunakan pelbagai ukuran klinikal dan subjektif; namun demikian, terdapat kekurangan bukti empirikal dan perbincangan yang menjelaskan mekanisme laluan penyakit mulut tertentu yang membawa kepada prestasi akademik yang buruk. Kajian ini membuat hipotesis bahawa karies gigi, yang beroperasi melalui kesakitan gigi, boleh mengganggu aktiviti pembelajaran dan mengakibatkan prestasi yang buruk di sekolah. Dua kajian, satu keratan rentas dan satu kawalan kes, telah dilakukan ke atas dua sampel pelajar sekolah yang tidak bertindih berusia 12-14 tahun di Jazan, Arab Saudi. Ukuran hasilnya adalah lulus/gagal GPA dan persepsi guru terhadap prestasi akademik kanak-kanak. Parameter dedahan merangkumi keadaan kesihatan mulut yang biasa pada kanak-kanak, yang dinilai dengan pemeriksaan klinikal dan soal selidik persepsi sendiri. Instrumen Child-OIDP juga disertakan untuk menilai impak keadaan kesihatan mulut terhadap aktiviti harian. Penemuan kedua-dua kajian itu konsisten dalam menunjukkan bahawa karies gigi, gingivitis, pengumpulan plak, sakit gigi, perubahan warna gigi, dan kesan kesihatan mulut yang berkaitan dengan aktiviti tidur dan belajar dengan signifikan dikaitkan dengan prestasi akademik. Hasil kajian juga menunjukkan bahawa karies gigi adalah keadaan mulut yang paling mungkin dikaitkan dengan prestasi akademik yang buruk. Nisbah ods untuk gagal dalam

peperiksaan adalah antara 3-6 kali lebih besar untuk setiap unit peningkatan dalam keterukan karies (OR_{lelaki} = 3.09; 95%CI: 2.25, 4.25, $OR_{perempuan}$ = 3.23; 95%CI: 2.48, 4.19 dalam kajian keratan lintang) (OR_{lelaki} = 6.34; 95%CI: 3.82, 10.50, $OR_{perempuan}$ = 5.26; 95%CI: 2.86, 9.66 dalam kajian kawalan kes). Analisis pengantaraan seterusnya menemui dua model yang menunjukkan kesan tidak langsung karies terhadap prestasi akademik. Sakit gigi dan tidur yang terimpak (Lelaki: bootstrap 95%CI: 0.02, 0.29) (Perempuan: bootstrap 95%CI 1.37, 12.81) dan sakit gigi dan aktiviti belajar yang terimpak (Perempuan: bootstrap 95%CI 0.10, 0.82) adalah mediator yang signifikan di dalam analisis pengantara dengan dua laluan. Penyiasatan perhubungan bersebab menggunakan kriteria Bradford-Hill telah menyokong model laluan; kesan langsung karies pergigian ke atas prestasi akademik tidak mempunyai rasional dan laluan melalui mediator menerangkan hubungan dengan lebih baik. Oleh itu, penemuan kajian ini menyokong hipotesis bahawa karies gigi berperanan dalam menjelaskan prestasi akademik yang buruk pada kanak-kanak yang mempunyai masalah kesihatan mulut dan ia beroperasi melalui perantara termasuk sakit gigi, dan aktiviti tidur dan belajar.

ORAL HEALTH STATUS AND ITS IMPACT ON ACADEMIC PERFORMANCE OF YOUNG ADOLESCENTS IN JAZAN, SAUDI ARABIA

Abstract

Apart from the physical and psychosocial impact, oral diseases in children have been linked to poor school performance that influences later life potential. Earlier studies have examined a range of oral health conditions using various clinical and subjective measures; nevertheless, there is a lack of empirical evidence and discussion explaining the pathway model of any specific oral health condition leading to poor academic performance. The current thesis hypothesized that dental caries, which operates through toothache, can disrupt learning activities and result in poor performance at school. Two studies, one cross-sectional and one case-control were carried out on two non-overlapping samples of schoolchildren aged 12-14 years in Jazan, Saudi Arabia. The outcome measures were a pass/fail GPA grade and teacher perception of the child's academic performance. The exposure parameters comprised the common oral health conditions in children, which were assessed by clinical examinations and a self-perceived questionnaire. The relationships between poor oral health-impacted sleep and study activities, and academic performance were also assessed. The findings of both studies were consistent in showing that dental caries, gingivitis, plaque deposits, toothache, tooth discolouration, and oral health impacts that are related to sleeping and studying were significantly associated with academic performance. The finding also showed that dental caries is the most likely oral health condition that can be linked to poor academic performance. The odds of failing the examination were between 3-6 times greater for every unit increase in decay severity (OR_{boys} = 3.09; 95%CI: 2.25, 4.25, OR_{girls} = 3.23; 95%CI: 2.48, 4.19 in the cross-

sectional study) (OR $_{boys}$ = 6.34; 95%CI: 3.82, 10.50, OR $_{girls}$ = 5.26; 95%CI: 2.86, 9.66 in the case-control study). Subsequent mediation analysis found two models indicating the indirect effect of caries on academic performance. Toothache and impacted sleep (Boys: bootstrap 95%CI: 0.02, 0.29) (Girls: bootstrap 95% CI 1.37, 12.81) and toothache and impacted study activity (Girls: bootstrap 95% CI 0.10, 0.82) were the significant mediators in the two-mediator pathway analysis. The investigation of a causal relationship using the Bradford Hill criteria had further supported the pathway models; the direct effect of dental caries on academic performance lacks rationale and the pathway through the mediators explain the relationship better. Thus, the findings of this thesis supported the hypothesis that dental caries has a role in explaining poor academic performance in children and it operates through mediators including toothache, and impaired sleep and study activities.

Chapter 1: Introduction

Oral health (OH) is an essential component of overall health and well-being.[1] Individuals with good OH are free from pain, infection, and diseases of the oral cavity, enabling them to carry out their daily activities.[2, 3] Any disease, deformity, or discomfort associated with oral tissues can influence them physically, psychologically and socially.[4, 5] Disabilities related to OH are prevalent in nearly half of the global population.[6] A wide range of diseases and conditions occur in the oral cavity of individuals, for example, dental caries, periodontal (gum) disease, tooth loss, oral cancer, oral manifestations of HIV infection, oro-dental trauma, and birth defects such as cleft lip and palate.[2] It is estimated that about 3.5 billion people worldwide suffer from oral diseases; a third with dental caries, making it the single most prevalent OH condition globally.[7, 8] OH conditions are more prevalent among low-income families, homeless people, prisoners, disabled people, and children.[9-13]

In children, dental caries, dental pain, and gingival inflammation are the most common OH conditions.[4, 6, 7, 14, 15] Dental caries in particular affect between 60% and 90% of children across the globe.[16, 17] The pain and discomfort caused by oral diseases in children can disrupt their patterns of sleeping, eating, playing, and resting.[18-22] Studies show that learning activities and performance in academics can also be affected by OH conditions.[23, 24] Education is essential in the development process of a child[25, 26] and, when disrupted, can result in long-lasting impacts that become apparent later in life. An educated individual has a broad range of opportunities in life. More specifically, education helps in personality development, improves mental and physical capabilities, and increases employment opportunities, which in turn

enables individuals to lead a prosperous life and contribute towards the development of a nation.[27, 28]

Academic performance is multifactorial and includes factors such as quality of learning environment, learning time spent, qualification of tutors and parents, family structure and income, and an individual's overall health.[29-31] The relationship between health and academic achievement is bidirectional. Children suffering from chronic illnesses and disabilities perform poorly academically, and those who are less educated tend to make unhealthy life choices, leading to premature morbidity and mortality.[30, 32] In line with this, it will be interesting to know whether oral conditions have an impact on the academic performance of children. So far, three systematic reviews highlight the studies examining the relationship between OH and academic performance.[23, 33, 34] Two of them demonstrate a strong association between OH conditions in children and their academic performance and attendance.[23, 24] However, a few issues remain unclear and require quantifiable and rational explanations. For instance, there lacks clear evidence to demonstrate which OH condition best explains poor academic performance; earlier reports have not presented a pathway model that could plausibly relate the two. This thesis attempts to bridge this gap in understanding, and the findings suggest that dental caries partly explains poor academic performance through toothache and the effects it has on sleep and study activities.

Chapter 2: Literature review

2.1 Introduction

This chapter starts with a brief description of the global burden and aetiology of oral diseases and the burden of common oral health (OH) conditions in children, including those of the population under study. It then presents a summary of the current understanding of the impact of OH on academic performance, appraises the reports relating to the association including the causal relationship. This is followed by the identification of knowledge gaps in the current understanding of the association. Finally, the hypothesis, conceptual framework and objectives of the thesis are presented.

2.2 Burden of Oral Diseases

Despite being preventable, oral diseases remain a public health challenge. The Global Burden of Disease Study 2017 indicates that over 3.5 billion people across the world are affected by OH conditions.[8] In another report, it was estimated that about 90% of individuals worldwide experience some form of the oral disease at least once in their lifetime.[35] OH problems include but are not limited to dental caries in primary and permanent dentitions, severe periodontal diseases, edentulism, severe tooth loss (between one and nine remaining teeth) and cancer of the lip and oral cavity.[36, 37] Among these, dental caries and periodontal diseases are more prevalent among individuals of all ages.[35, 36] The estimated number of people affected by untreated dental caries in primary and permanent dentitions are 573 million and 2.5 billion, respectively.[8, 36] Those suffering from severe periodontal diseases and tooth loss include 538 million and 276 million, respectively,[8, 36] while 139 million suffer from other OH conditions.[8] Overall, the prevalence of oral diseases is similar in both sexes and varies by age. The prevalence of dental caries in primary and permanent dentitions peaks at 5 years of age and between 20 and 24 years of age, respectively. Periodontitis and tooth loss are mostly observed in older populations and are at their highest at 60-64 years and 80-89 years, respectively.[8] The trend of OH conditions shows that there has been no overall improvement in 25 years (from 1990 to 2015) (Table 2.1), except that the prevalence and incidence of untreated caries in deciduous teeth decreased slightly from the year 1990 (8.2%) to 2015 (7.8%).[36] With 34.1% of individuals being affected, untreated dental caries in permanent dentition remains the most prevalent OH condition globally.[4]

Table 2.1: Global changes in the number of OH conditions from 1990 to 2015.

*Global prevalence of OH conditions	1990		2015	
Prevalent Cases	N in millions	Range in millions	N in millions	Range in millions
Untreated caries in permanent teeth	1739 (34.3)	(1623–1845)	2521 (34.1)	(2361–2680)
Untreated caries in deciduous teeth	555 (8.2)	(469–655)	573 (7.8)	(475–687)
Severe periodontitis	307 (7.4)	(267–357)	538 (7.4)	(465–626)
Total tooth loss	157 (4.3)	(151–164)	276 (4.1)	(264–288)
All oral conditions	2513 (48.4)	(2472–2551)	3522 (48.0)	(3467–3575)
Incident cases	N in millions	Range in millions	N in millions	Range in millions
Untreated caries in permanent teeth	627	(589–665)	616	(577–656)
Untreated caries in deciduous teeth	129	(98–169)	126	(94–167)
Severe periodontitis	6	(5-7)	6	(5–6.6)
Total tooth loss	3	(3-3)	3	(3-3)
All oral conditions	764	(713–820)	750	(700–808)

*Age-standardized prevalence and incidence (adapted from the Global Burden Study 2017).[36]

The country-wise data on age-standardized untreated caries in permanent dentition suggests that Latin American, European, and several Asian countries have higher rates in comparison to other nations.[4] In many low- and middle-income countries, the differences in lifestyle and living conditions compared to high-income countries along with poor access to healthcare contributed significantly to the burden of oral diseases.[38] Saudi Arabia is currently regarded as a high-income country, however, the prevalence of oral diseases, including dental caries, is substantially greater in comparison to that of other high-income countries (Figure 2.1).[4] Further, reports suggest that within the population of a region or country, a higher prevalence of oral diseases is usually observed among low-income, homeless, prison-dwelling, disabled,

and children.[9-13] In children, dental caries, toothache associated with pulpal infections, and gingival inflammation are more common than other OH conditions.[38] If left untreated, these OH conditions impact the development of a nation and also its citizens.

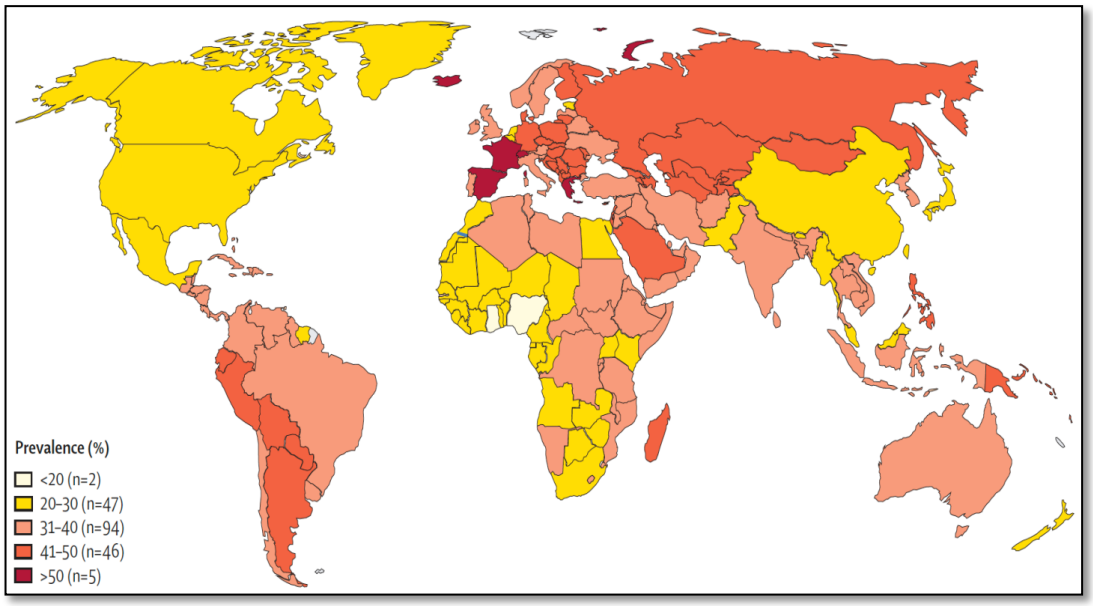

Figure 2.1: Estimated age-standardized global prevalence of untreated dental caries in permanent teeth for 2017 (Adapted from Peres et al; 2019).[4]

2.3 Oral Diseases in Children

2.3.1 Dental Caries

Dental caries is a multifactorial disease characterized by the destruction of tooth structure due to demineralization by acid-producing bacteria.[39, 40] The Keyes model (Figure 2.2) describing the interaction between host saliva and teeth, microflora, and diet/substrate has not changed appreciably since 1963.[41] Early studies suggested that *streptococci* cause dental caries,[42, 43] but recent clinical and epidemiological evidence showed that the cause cannot be attributed to any single microorganism.[44, 45] A more recent socio-ecological model for caries includes an array of determinants that demonstrate an interplay of the individual (level of education, OH behaviour, diet,

oral cavity environment, etc) and community-level factors (socioeconomic characteristics, dental care system, health-promoting environment, etc).[46, 47]

Caries can be measured using several indices including the Decayed, Missing, and Filled Teeth (DMFT) index, the International Caries Detection and Assessment System, the Significant Caries index, and the pulpal involvement, ulceration, fistula, and abscess index.[4, 48] Because of its ease in application, the DMFT index variants, including one or more decay, missing, filled prevalence and decay severity (DMFT, DT, MT, and FT) are used in most epidemiological studies.[49]

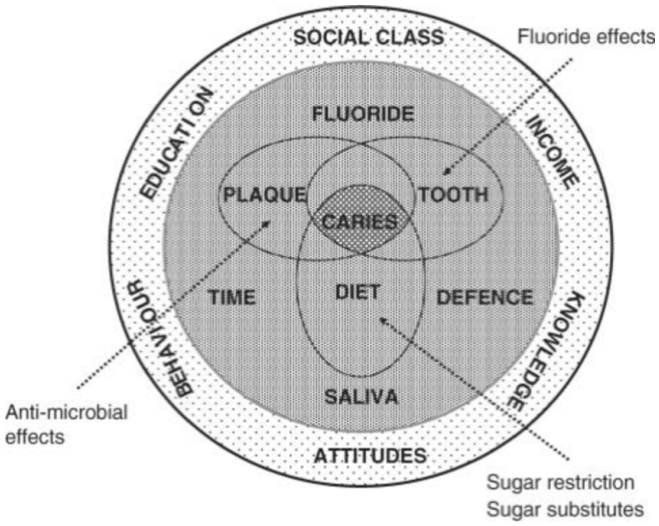

Figure 2.2: Modified Keyes model for the prerequisites for caries development (Adapted from Keyes, 1963).[41]

Caries prevalence in children varies between countries; based on income per capita, it is comparatively higher in lower- and middle-income countries (LMIC's) than in high-income countries (HIC's).[4, 50] A recent report on caries distribution, which included studies published between 1995 and 2019, showed that the overall prevalence was lower in the primary than permanent dentitions and that more children

in Asian and African continents had decayed primary and permanent dentitions than children from other continents (Table 2.2).[51]

Table 2.2: Prevalence of dental caries in primary and permanent teeth in children in different continents, from the year 1994 to 2019.[51]

Tooth type	Continents	Number of articles	Sample Size (N)	Prevalence %
Caries in primary teeth	Asia	50	54,680	52.6 (95% CI: 46.7–58.5)
	Europe	10	9977	21.4 (95% CI: 15.3–29.1)
	America	14	6825	45.8 (95% CI: 34.2–58)
	Africa	5	3004	53.1 (95% CI: 44.3–61.7)
	Australia	3	6472	28.5 (95% CI: 20.3–38.5)
Caries in permanent teeth	Asia	50	1,334,133	58.8 (95% CI: 53.4–64)
	Europe	22	115,141	44.1 (95% CI: 36.1–52.5)
	America	7	5009	48.9 (95% CI: 37.6–60.3)
	Africa	5	2794	58.9 (95% CI: 29.4–83.1)
	Australia	1	612	54.9 (95% CI: 50.9–58.8)

Regionally, SEARO (1.1 to 2.9) and EMRO (1.5 to 1.6) registered an increase in caries experience (DMFT) among 12-year-olds between the years 2004 and 2015 (Table 2.3).[52, 53] The EMRO region comprises Afghanistan, Bahrain, Djibouti, Egypt, Iran, Jordan, Kuwait, Lebanon, Libya, Morocco, occupied Palestinian territory, Oman, Pakistan, Qatar, Somalia, Sudan, Syria, Tunisia, United Arab Emirates, Yemen, and *Saudi Arabia*.

Table 2.3: Mean DMFT among 12-year-olds in the WHO-specified regions.[52, 53]

WHO Regions	*DMFT		
	2004	**2011**	**2015**
AFRO	1.15	1.19	1.06
AMRO	2.76	2.35	2.08
EMRO	1.58	1.63	1.64
EURO	2.57	1.95	1.81
SEARO	1.12	1.87	2.97
WPRO	1.48	1.39	1.05
Global	**1.61**	**1.67**	**1.86**

*Mean DMFT
AFRO: WHO Regional Office for Africa
AMRO/ PAHO: WHO Regional Office for the Americas
EMRO: WHO Regional Office for the Eastern Mediterranean
EURO: WHO Regional Office for Europe
SEARO: WHO Regional Office for South-East Asia
WPRO: WHO Regional Office for the Western Pacific

Within a nation, dental caries distribution varies by the sociodemographic characteristics of its population.[54-57] The prevalence and incidence increase with age in both primary and permanent dentitions. This trend is followed by a sharp decline after the age of 5 years in primary dentition. In permanent dentition, the incidence and prevalence are seen to rise through the age of 12-15 years and reach the peak level at around 25 years and 15 years, respectively (Figure 2.3).[6] Children studying in public schools (PR = 4.9; 95%CI: 3.38, 7.23) and those who belong to families earning minimum wage (PR = 1.25; 95%CI: 1.08, 1.44) showed a significantly greater prevalence ratio than their peers.[58] Another report suggests that the need for treatment for caries and missing teeth are 30% and 60% greater, respectively, in children residing in socially deprived areas.[59] Overall, about 60% of untreated caries were observed to be concentrated in 20% of children, all of whom were underprivileged.[58, 60]

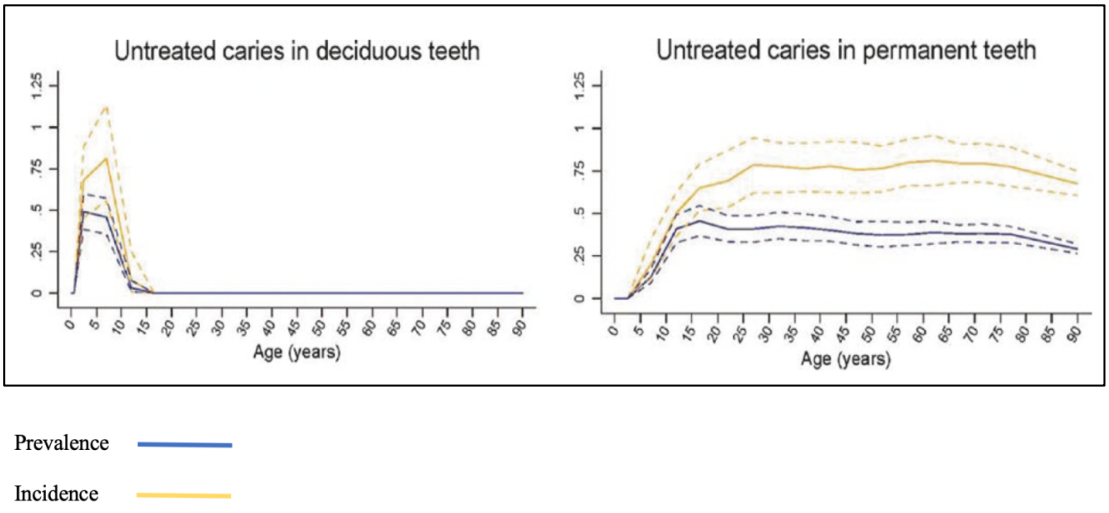

Figure 2.3: Global prevalence and incidence rates of oral conditions by age in 2015 (Adapted from Peres et al, 2021).[6]

In Saudi Arabia, the prevalence of dental caries in children is substantially high despite being a high-income nation (World bank data: per capita of $12,736 or more).[61-66] Nationwide surveys indicate that caries prevalence increased from 74% in the year 1999 to 80% in the year 2010, with a mean DMFT score ranging from 1.5 to 2.9.[67, 68] There was no difference in caries prevalence between the urban and rural areas of Riyadh province ($p > 0.05$), with an overall caries prevalence of 85.8%, 65%, and 71.3% among the 6-, 12-, and 15-year-olds, respectively.[69] However, the caries experience in children is different between Riyadh province (dft/DMFT=5.1)[70] and a less developed region (dft/DMFT=7.1).[71]

2.3.2 Toothache/Dental Pain

Toothache, or dental pain, is a sequela of dental caries often experienced by children of all ages.[72, 73] It is manifested by "unpleasant, subjective sensory and sensitive sensation connected with real or potentially damaged tooth structure",[74, 75] mostly of severe nature.[76-78] Toothache originating from dental caries is regarded as the most

common orofacial pain.[77, 79, 80] It has two forms: acute pain, which is more intense in nature and reversible upon the removal of stimulus, and chronic pain, which is characterized by a dull ache that is irreversible and often involves deep cavitated lesions in teeth or swelling of infected soft tissues.[72, 73] Toothache is measured subjectively and is manifested according to levels of fear and anxiety, which can be detected via a combination of signs and symptoms, including dilation of the pupils, lacrimation, tachycardia, hypertension, nausea, vomiting, auditory sensations, and grimaces.[72, 73]

The prevalence of toothache increases with age, caries severity, and lower socioeconomic status.[76] Children with more caries are more likely to experience toothache.[77, 81] Some reports from developed nations show that toothache is more prevalent in the lower socioeconomic groups.[76, 79, 82, 83] The data on the epidemiology of toothache in the Saudi Arabian paediatric population is limited. Studies showed that nearly 63% of 6- to 8-year-olds in Riyadh, Saudi Arabia[66] and 12-year-olds in Jeddah, Saudi Arabia (mean age = 12.1 years)[84] experienced toothache.

Toothache can be a disabling condition that affects children's daily activities;[85] causes avoidance of certain foods, disruption of sleep,[86, 87] reduction in socialising and impairing a child's ability to carry out routine work.[88, 89] Schuch et al. (2014), stated that toothache may negatively impact a child's emotional status and disrupt their ability to learn.[90]

2.3.3 Periodontal Diseases

Periodontal diseases are disorders of tooth-supporting structures (Figure 2.4)[91] that start with gingival inflammation due to plaque and progress to loss of soft tissue, loss of supporting bone, pocketing, loss of attachment, and, ultimately, tooth loss.[92, 93] The most prevalent risk factors of gingival inflammation include the presence of plaque biofilm on the surface of the teeth, oral hygiene and behavioural issues, and long-term systemic conditions.[94-98] If allowed to persist, over time, these conditions may lead to clinical attachment loss and tooth loss.[99] However, this process may aggravate depending upon several other host-related factors, such as stress, poor nutrition, poor oral hygiene, diabetes, and certain medications.[100]

Periodontal health in children is usually reported using the Community Periodontal Index of Treatment Needs (CPITN) or the Gingival Index (GI).[101, 102] Between them, the GI is quicker for recording data and more appropriate for younger-aged individuals.[103] Further, factors contributing to gum inflammation, such as the deposition of plaque, are considered while measuring the GI.[104] The oral hygiene indices include those proposed by Ramfjord (1959), Green-Vermillion (1960), and Loe and Silness (1967); however, the Loe and Silness plaque index, which categorizes the thickness of the soft deposits on the surfaces of the teeth, is based on a similar principle to the gingival index.[104]

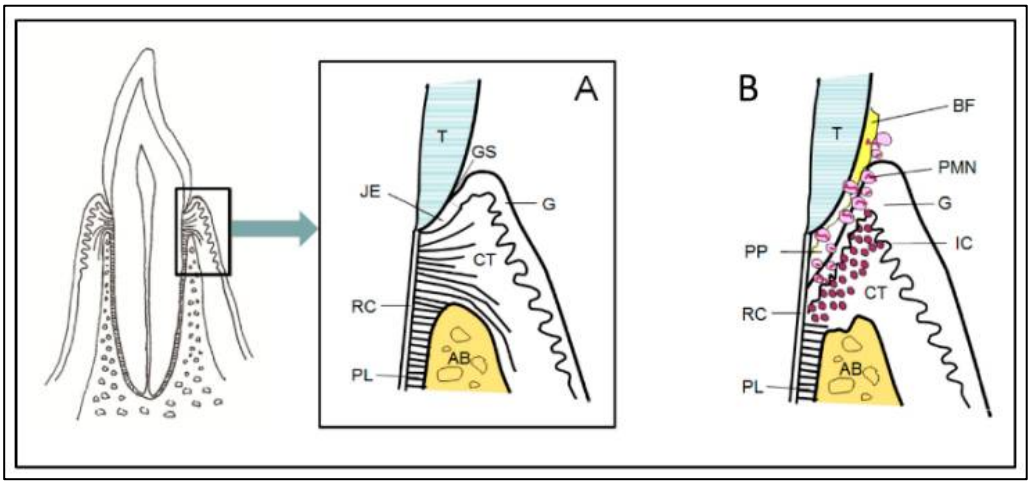

Figure 2.4: The tooth and its supporting structures (Adapted from Kononen et al; 2019).[105]
The anatomical structure of periodontium in health (A) and periodontitis (B).
Abbreviations: Alveolar bone (AB), Bacterial film (BF), Connective tissue (CT), Gingiva (G), Gingival sulcus (GS), Inflammatory cells (IC), Junctional epithelium (JE), Polymorphonuclear neutrophils (PMN), Periodontal ligament (PL), Periodontal pocket (PP), Root cementum (RC), and Tooth (T).

Globally, periodontal disease is more prevalent in the adult population, whereas gingivitis, with diverse levels of severity, is more common in children and adolescents (Figure 2.5 and Figure 2.6).[95, 106-109] Figure 2.5 further depicts that as the age increases the prevalence of gingivitis decreases, and that of periodontitis increases. The prevalence trend of tooth mobility according to age is similar to that of periodontitis. Additionally, Figure 2.6 illustrates that the mean clinical attachment loss in children and adolescents (age: 15-24 years) is the least. This data further substantiates that gingival inflammation with no bone involvement is more common than the periodontal disease in children.

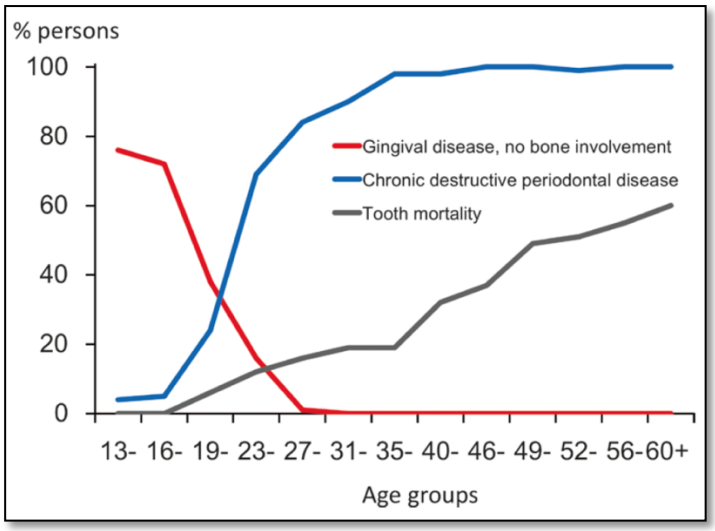

Figure 2.5: The distribution of gingival disease, destructive periodontal disease, and tooth mortality according to age (Adapted from Peres et al; 2021).[6]

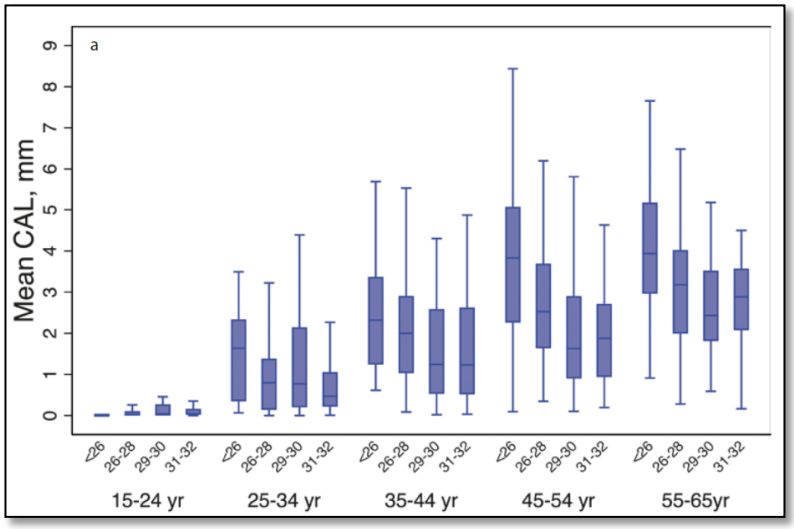

Figure 2.6: Box plots showing the distribution of the mean clinical attachment loss (CAL) in various age groups (Adapted from Peres et al; 2021).[6]

Studies of periodontal disease rates in the paediatric population of Latin America and parts of China reported that the prevalence of gingival inflammation in children and adolescents in those regions ranged between 23% and 100%.[110-112] A 2018 study found that about 80% of school-going children in Puerto Rico had gingivitis, and slightly more boys (81.3%) than girls (79.6%) suffered from bleeding gums.[113] Children attending urban public schools (83.2%) in comparison to urban private

(79.15%) and rural public schools (77.59%), had a higher prevalence of gingivitis,[113] which reportedly peaks between the ages of 11 and 13 years in girls and between 13 and 14 years in boys.[113, 114] In Saudi Arabia, a survey revealed that 90% of children had gum problems, of whom 14% experienced moderate to severe gingival inflammation.[63] Schoolchildren aged 12-15 years in Saudi Arabia have been found to have a higher prevalence of plaque accumulation (52%) and calculus deposits (50%) with a higher prevalence of moderate to severe gingivitis (48.7%), in comparison to other age levels.[115]

The literature reviewed here suggests that OH conditions in children remain a major burden globally, including in Saudi Arabia. Although the United Nations urges its member countries to consider OH a public health priority,[116] policymakers of some countries still regard it as a marginal issue.[14] If untreated, these OH conditions can impact children's daily activities and quality of life, burden the lives of parents and caregivers, and ultimately affect a nation's economy.

2.4 Impact of Oral Health Conditions

Currently, oral health (OH) conditions contribute 1.2% of the disability-adjusted life years (DALY) lost worldwide; a 70% increase since 1990.[117] Persistent OH conditions in children impact a country's economy, as the direct cost of treating them increases healthcare expenditure by 5%-10%.[17] In the latest global aggregate cost of treatment, about 82% of $297.67B was shared by high-income countries including Saudi Arabia.[118] Further, the data for many Middle Eastern countries indicates that OH conditions contribute to the highest proportion of productivity loss in their respective nations.[118] Dental caries is the fourth most expensive disease to treat, and amongst the

OH conditions, it is the most expensive.[119-121] Oral health conditions in children also affect their parents. The 2013 Children's Dental Health Survey of England, Wales, and Northern Ireland found that one-fifth of families in which there were children with untreated OH conditions had financial difficulties, spent more time addressing the children's OH problems, and took time off from work more frequently.[122] At the individual level, children experiencing persistent OH conditions have a poor quality of life and impaired regular activities such as eating, speaking, brushing teeth, sleeping, and attending school.[123] [124, 125] There are also studies showing the relationship between OH and school or academic performance.[23, 24]

2.4.1 Impact on Quality of Life (QoL)

Quality of life (QoL) studies were introduced to measure a broader perspective of change in an individual or population than the conventionally investigated clinical changes.[1] The concept of QoL preceded the Health-Related Quality of Life (HRQoL) and the OHRQoL constructs and has been incorporated in the medical literature since 1960.[126, 127] In general, QoL is an individual's subjective determination of satisfaction with their life,[128] and as stated by the World Health Organization (WHO): "*perceptions of their position in life in the context of culture and value systems in which they live, and in relation to their goals, expectations, standards, and concerns*".[129]

OHRQoL can be represented by five dimensions; OH symptoms, functions, treatment expectations, environment and social/emotional status (Figure 2.7), and each of these dimensions can be influenced by untreated OH conditions.[130] There are several OHRQoL tools that are used extensively in the field of dental public health.[131-140] The

three most commonly used are: the Child Perception Questionnaire (CPQ), Child-OIDP, and the Child-OHIP.[1, 141-143] Psychometric analysis showed that all three are reliable and valid for their use in cross-sectional and population-based studies.[141]

Figure 2.7: Dimensions comprising oral health-related quality of life (Adapted from Sischo and Broder, 2011).[130]

The CPQ 11-14 is one of the earliest OHRQoL tools and consists of four domains: oral symptoms, functional limitations, emotional well-being and social well-being and it measures the impact on learning and school activities using four questions.[143, 144] The Child-OHIP comprises five domains namely; oral symptoms, functional well-being, emotional well-being, peer interaction and school (uses four school-related items).[145] The Child-OIDP focuses on the physical impacts of OH conditions on eight daily activities: eating, teeth cleaning, speaking, smiling, sleeping, emotional stability, doing schoolwork/study, and social contact.[136]

Both, the Child-OHIP and the CPQ 11-14 measure the frequency of events in the past three months using four similar questions related to school and academic activities: missing school lessons, difficulty in paying attention, difficulty in doing homework, and not wanting to read aloud in the class.[146, 147] In comparison, the Child-OIDP measures prevalence, frequency and severity of the impacts on daily activities but for only one item; study or schoolwork. Additionally, the impact is also assessed using a score based on frequency and severity (oral impact score);[136] which is directly related to the *role of severity of events* in the relationship, and this has been emphasized in an earlier report.[34] The Child-OIDP also has better content validity which is attributed to its strict compliance with the concepts of "disability" and "handicap" from Locker's model.[141] Therefore, it has a better advantage compared to the other two tools in the investigation of the impact of OH conditions on academic performance.

Child-Oral Impact on Daily Performances (Child-OIDP)

The Child-OIDP was developed in 2004 and has been tested and validated in numerous languages,[134, 148-152] including Arabic.[153] Similar to the version for adults, the Child-OIDP assesses the OH impact on eight activities, except that the impact on *carrying out work* in adults is replaced with *study or schoolwork* in children.[22, 154] Also, the recall period in Child-OIDP is reduced to three months in comparison to six months in the OIDP tool for adults.[136, 142]

Several reports on the impact of OH conditions on schoolwork using the Child-OIDP assessment tool are presented in Table 2.4. The proportion of children whose schoolwork was impacted by OH conditions ranged from 1.8% to 15.6%, with the highest proportion being reported by a Saudi Arabian study.[155] However, the tool is

neither designed nor has a validated measure to assess the impact on academic performance. It only infers that OH can impact study activities which includes school attendance, homework, and focus in class and during the learning process.[156]

Table 2.4: Studies reporting the proportion of children with impacted study activity due to oral health conditions.

Author	Sample size and age	Proportion
Gherunpong et al., 2004[22]	• 1101 Schoolchildren • 1034 completed survey • 11- to 12-year-olds	15.4%
Yusuf et al., 2006[139]	• 228 schoolchildren • 10- to 11-year-olds	1.8%
Bernabe et al., 2007[157]	• 805 schoolchildren • 11- to 12-year-olds	17%
Castro et al., 2008[134]	• 342 schoolchildren • 11- to 14-year-olds	6.7%
Krisdapong et al., 2009[156]	• 1066 schoolchildren • 12- and 15-year-olds	12-year-olds: 5.5% 15-year-olds: 5.9%
Nurelhuda et al., 2010[153]	• 1109 schoolchildren • 12-year-olds	7.7%
Basavaraj et.al., 2014[150]	• 900 schoolchildren • 12- to 15-year-olds	4.1%
Saujanya et. al., 2018[158]	• 1052 schoolchildren • 12- to 15-year-olds	5%
Kassim et al., 2019[155]	• 186 schoolchildren • 9- to 11-year-olds	15.6%

2.5 Academic Performance

In this section, the concept and definition of academic performance in schoolchildren and factors that influence it are presented.

The terms "school performance" and "academic performance" are used interchangeably in the earlier studies investigating its relationship with OH,[23, 24, 34] and in one report both terms were used.[159] The term 'school performance' is sometimes

referred to as an achievement of a school when comparing between schools' standards of education and learning, and academic grades, which are then presented as league tables for providing information to the parents about the quality of a school.[160, 161] Another use of the term is to report on the quality of the learning environment and teachers' characteristics and experience in schools.[162] Whereas, in most psychology and behaviour journals, academic performance is referred to as the marks or grades achieved by a child during their assessments or examinations and is differentiated from school performance.[163-166]

Academic performance; also referred to as academic achievement, is an outcome measure that captures the quality of academic work of a student, including the level of knowledge, and cognitive and affective skills.[167, 168] It is one of the six key components of academic success: academic achievement/performance, satisfaction, acquisition of skills and competencies, persistence, attainment of educational outcomes, and career success (Figure 2.8).[167] Academic performance is often measured objectively through standardized tests or examinations and reported in a cumulative form as grades or grade point average (GPA).[167] Sometimes, academic performance is also measured subjectively through self-assessment and teacher ratings.[169, 170] Teacher rating scales can be used to judge a range of academic tasks, such as following a tutor's commands, level of concentration, and responsiveness during lectures.[171] By far, the standardized GPA or examination grades are the most common measures to assess academic performance, and the subjective measures are used additionally as feedback on academic-related activities.[167] In this thesis, both terms are applied; with *academic performance* specifically focussing on exam-based assessment.

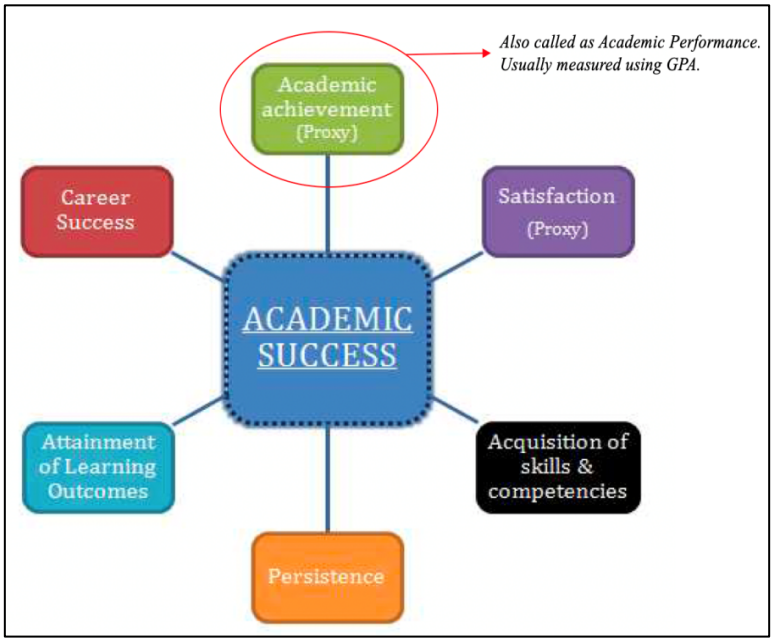

Figure 2.8: Conceptual Model of Academic Success (Adapted from York et al; 2015).[167]

Numerous factors individually or collectively influence the academic performance of children and they are broadly classified into factors related to the student, family, school, and peers.[172] More specifically, academic performance is shown to be associated with sex,[173] ethnicity,[174] intelligence quotient (IQ),[175, 176] nutrition,[175] parents' occupation, and education,[29, 177] family socioeconomic status,[29, 178] family size, school learning environment, and socialization with peers.[29, 179] The earliest investigations on the relationship between school performance and general health in children were reported in 1985.[180, 181] It was suggested that chronic illness affects both academic achievement and attendance. Illnesses with accompanying psychological difficulties were associated with poor academic achievement, whereas those that prevented strenuous activities influenced school attendance.[180, 181]

2.6 Oral Health and Academic Performance

This section presents the review of literature that was carried out while conceptualizing the study in the year 2016/2017 and was updated more recently (2020).

2.6.1 Past Review of Literature on the Association Between Oral Health and Academic Performance

The method to identify the literature relevant to the thesis was adopted from that of a systematic review and follows the selection process as presented in Figure 2.9.[182] The guiding question for the literature search, according to the Population/Intervention/ Comparison/Outcomes/Study Design (PICOS), was "Do children and adolescents (population) with oral health problems (intervention) have poor academic performance (outcome) compared to children without oral health problems (comparison)?"

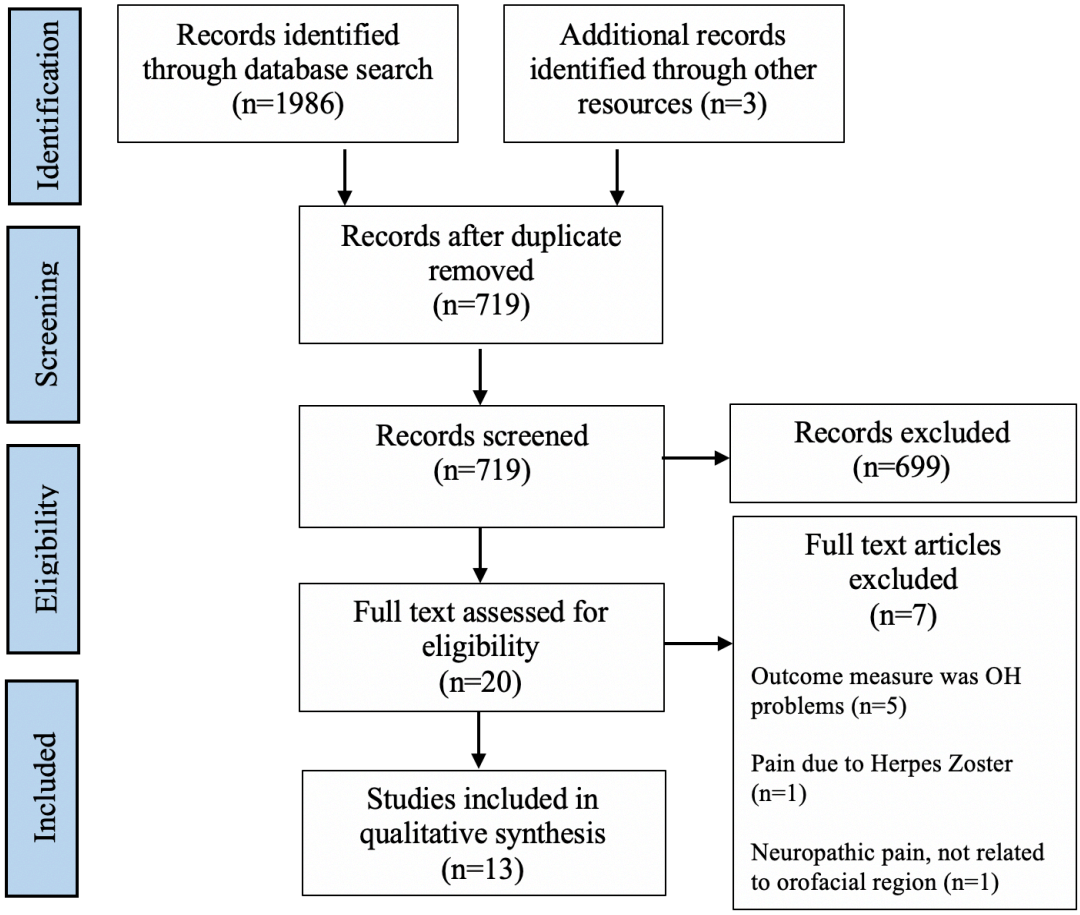

Figure 2.9: PRISMA flow-chart illustrating the study selection process.

Online searches for the reports were carried out using EndNote–X8 and included searches in the Medline (NLM), Web of Science (SCI-TR-Core collection), CINAHL, and Scopus databases (Table 2.5). Multiple searches were performed using various combinations of keywords including the MeSH terms and there was no restriction with regards to publication dates. The reports identified from the reference list of retrieved articles were also included and secondary searches with similar keywords were carried out in the Google scholar database. The search conducted comprised key terms according to the pre-established PICO/S acronym. The specific subject headings index from different databases (MeSH terms, Emtree terms, and PsycINFO Thesaurus) and their synonyms were identified. The Boolean operators AND / OR

were used in combining the identified search terms. Two researchers carried out independent searches and managed, stored, and organized the references using EndNote software (https://www. myendnoteweb. com/).

Search Terms

In this study, *school or academic performance* (AP) is a generic term that refers to academic achievement at school which may include a range of subjective and objective measures that relate to examination scores or academic-related indices. Oral health (OH) status refers to any oral outcomes based on clinical or perceived assessment. The term 'relationship' refers to the impact of OH status on academic performance.

Table 2.5: Description of the search terms used in retrieving the reports.

	Databases	**Search terms**
#1	Medline, Web of Science, CINAHL, Scopus, Google Scholar	Academic performance OR School performance OR Academic failure OR Academic success OR Academic achievement
#2		Oral health OR Dental health OR Dental health status OR Oral health status OR Mouth disease OR Dental caries OR Dental pain OR Tooth pain OR Dentalgia OR Gum disease OR Gingivitis OR Periodontal diseases
#3		Child OR School OR Schoolchildren OR Adolescent
#4		#1 AND #2 AND #3

No limiters were used.